Reversing the Balkanization of Store and Forward Networking

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Store and Forward (S&F) Networking

- Forwarding vs. Circuits
  - A separate forwarding decision is made on every quantum (packet, datagram, file)
- Storage vs. Switching
  - A quantum may reside at a node for a period of time that is not bounded a priori

S&F Balkanization Preceded IP Routing

- Before IP routing, many network services were application level S&F
  - E.g. E-mail, Network News
- Routing was implemented in an application-specific manner
- Forwarding infrastructure: uucp or BITNET
- Storage infrastructure: local file system

IP Forwarding Emulates Switching, Hides Buffers

- End-to-end IP datagram delivery is the unifying service of the Internet
- Buffering is suppressed as part of the model
- TCP assumes minimal forwarding delay
- Explicit storage is pushed to App Layer
- Balkanization of S&F networking persists
  - Mail, News, Web Caching, Content Delivery…

Scalability and the End-to-End Principles

- The end-to-end principles have guided the design and dominance of IP
- "The network should not be specialized to support a subset of applications."
- This was one motivation for the splitting of IP and TCP (layers 3 and 4)
- A generic, transparent network can support unanticipated application requirements

Commonality Among S&F Applications

- Delay Tolerant Networking requires spooling at points of disconnection
- Content Distribution uses long-lived buffers for localization & overlay multicast
- Temporary files are a S&F send-to-self
- Non-synchronous streaming requires significant buffering
- Do our S&F solutions unify or balkanize?

What is Logistical Networking?

- A scalable mechanism for deploying shared storage resources throughout the network
- A general store-and-forward overlay networking infrastructure
- A way to break transfers into segments and employ heterogeneous network technologies on the pieces

Models of Sharing: Logistical Networking

Moderately valuable resources

- Storage, server cycles

Sharing enabled by relative plenty

Internet-like policies

- Loose access control
- No per-use accounting

Primary design goal: scalability

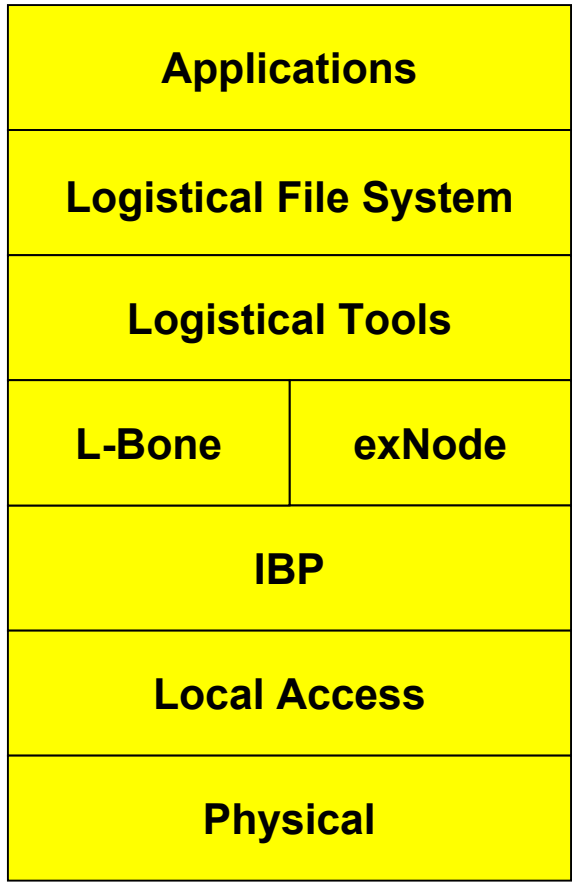
- Application autonomy
- Resource transparency

Burdens of scalability

- The End-to-End Principles
- Weak operation semantics
- Vulnerability to Denial of Service

The Network Storage Stack

- Our adaptation of the network stack architecture for storage
- Like the IP Stack
- Each level encapsulates details from the lower levels, while still exposing details to higher levels



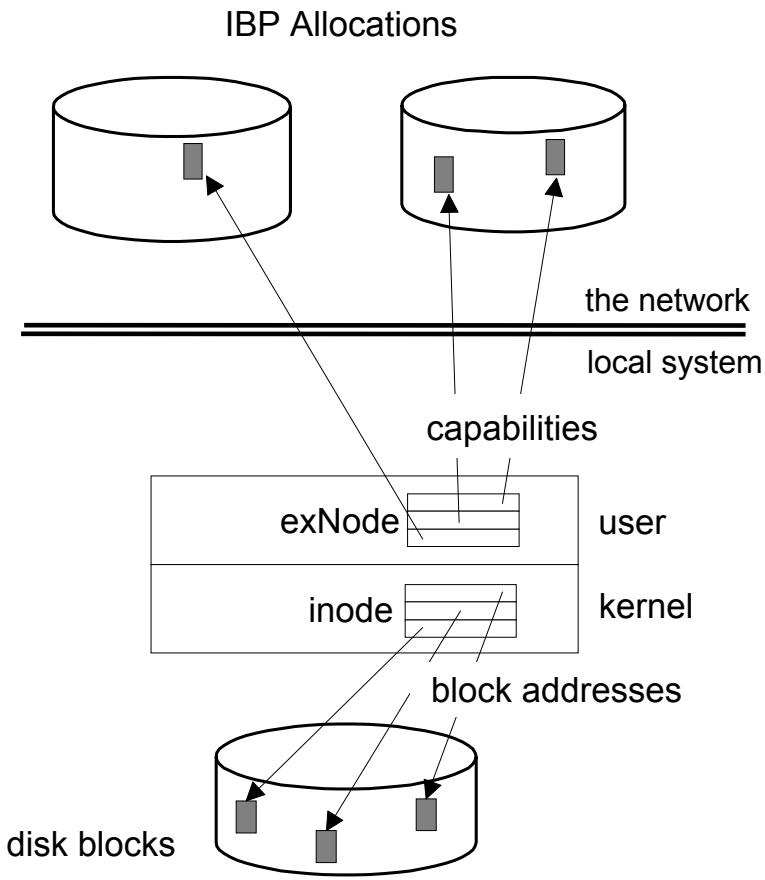
IBP: The Internet Backplane Protocol

- Storage provisioned on community “depots”
- Very primitive service (similar to block service, but more sharable)
  - Goal is to be a common platform (exposed)
  - Also part of end-to-end design
- Best effort service – no heroic measures
  - Availability, reliability, security, performance
- Allocations are time-limited!
  - Leases are respected, can be renewed
  - Permanent storage is to strong to share!

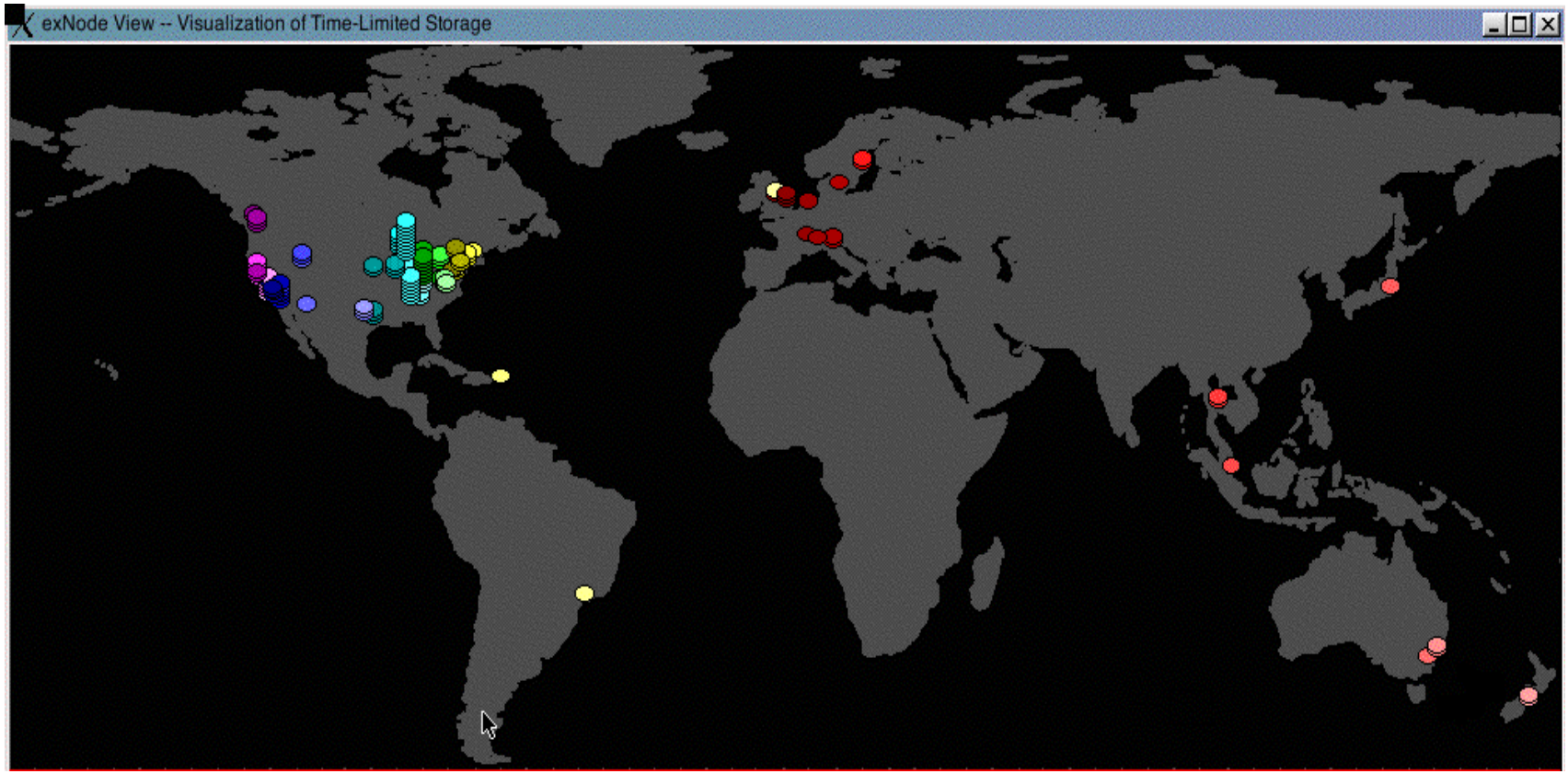
The exNode

- The Network "File Descriptor
- XML-based data structure/serialization
- Map byte-extents to IBP buffers (or other allocations).
- Allows for replication, flexible decomposition of data.
- Also allows for error-correction/checksums
- Arbitrary metadata.

ExNode vs inode



L-Bone: January 2003



Current Storage Capacity: 13 TB

Conclusions

- If we ignore the End-to-End Principles we may sacrifice scalability & generality
- Adapting a special-purpose as a general mechanism can enshrine compromises
- Logistical Networking is a Store & Forward service designed for generality
- Balkanization can be overcome by discipline and community

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